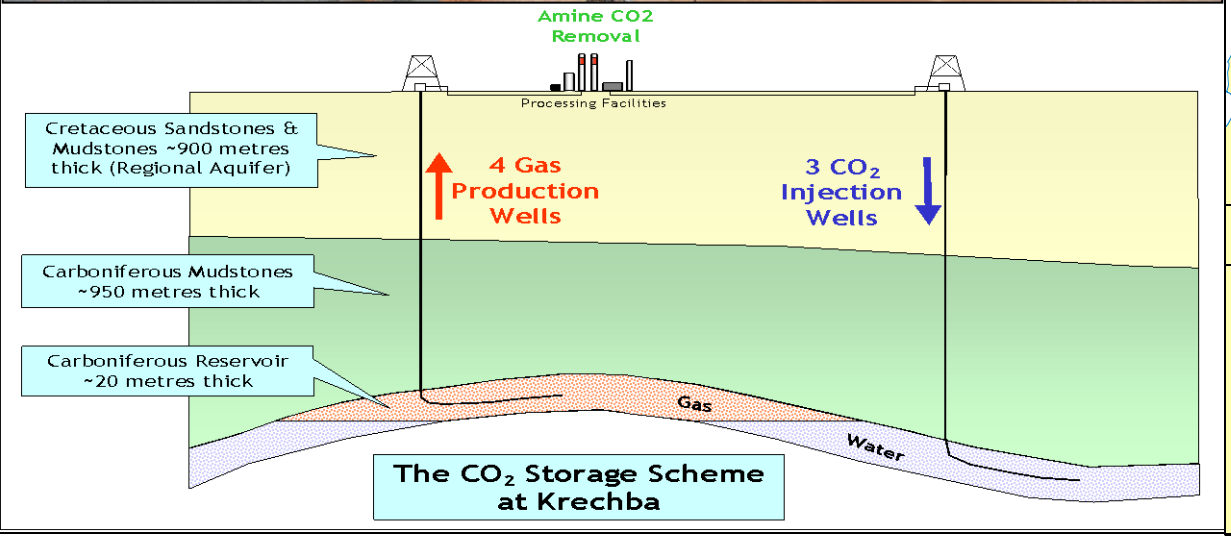
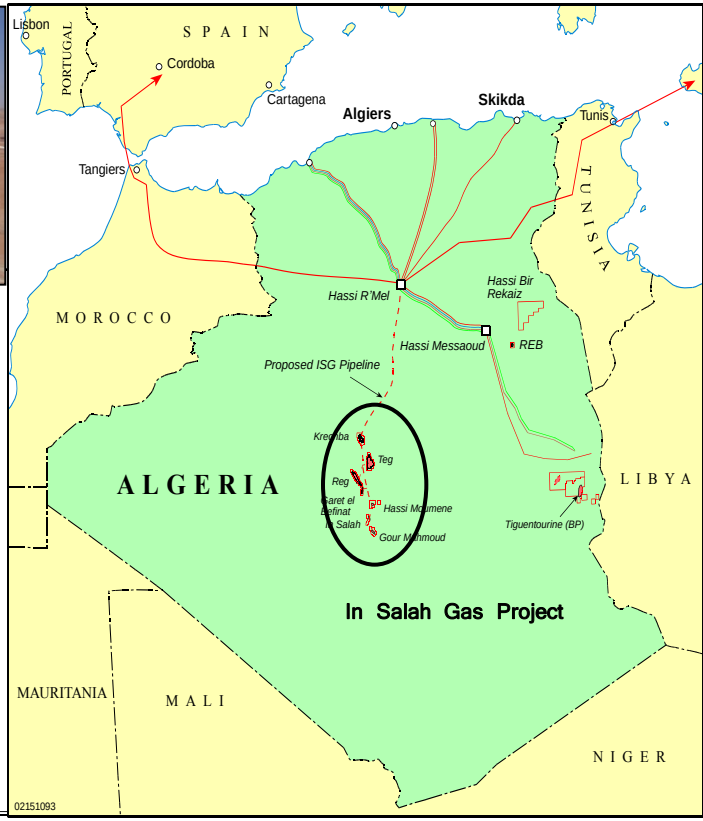
Agenda

- In Salah CCS: Project Description
- Site Selection and Management
- Monitoring Stored CO_2: Joint Industry Project
- Key Lessons Learned from Phase 1
  - Well Integrity: KB-5
  - Seismic Interpretation
- Plans for Phase 2
- Questions/Answers

Project Overview

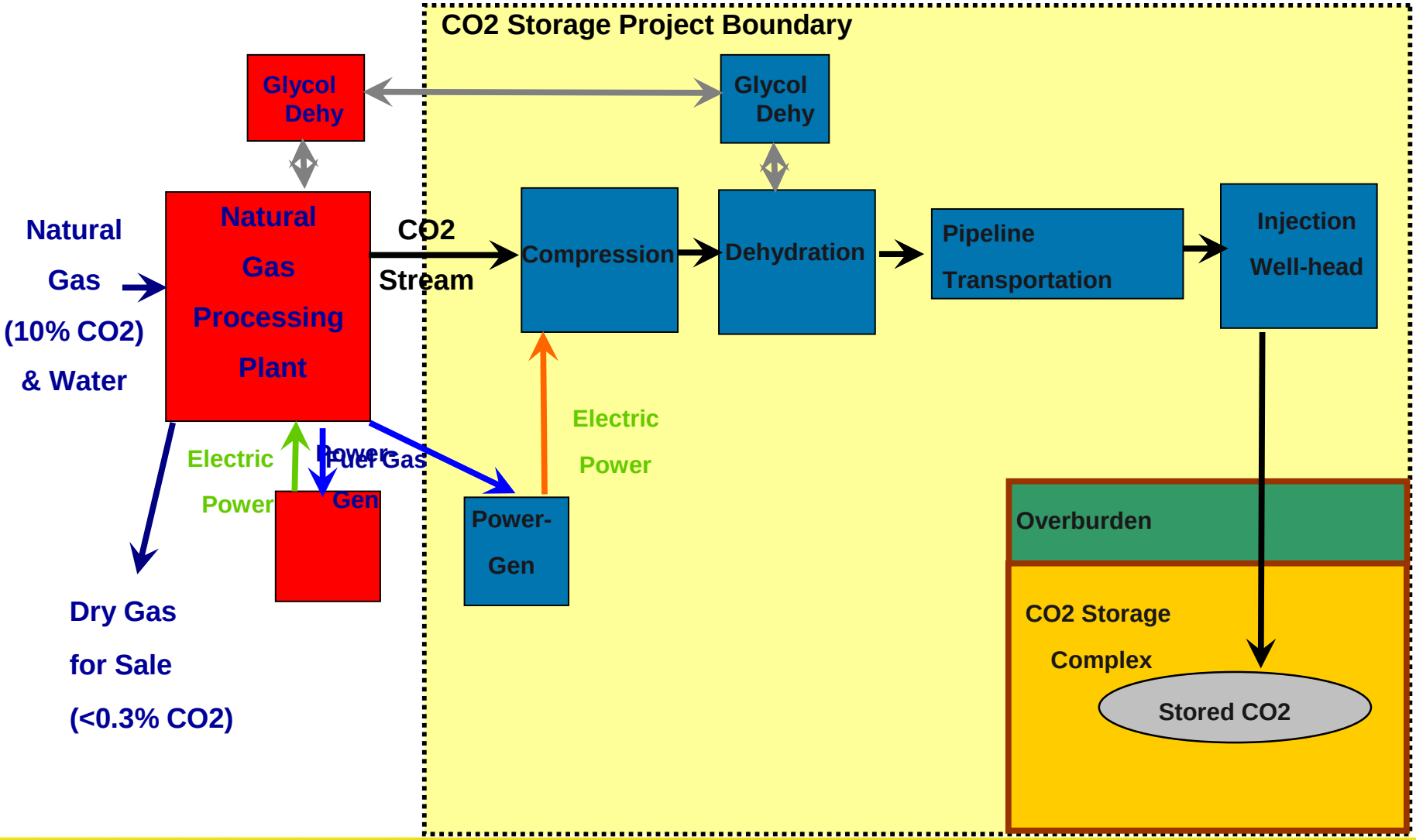




Project Fun Facts

- Industrial Scale Demonstration of CO_2 Geological Storage (Conventional Capture)
- Storage Formation is common in Europe, USA & China
- Started Storage in August 2004
- 1mmtpa CO_2 Stored (17mm tonnes total)
- $100mm Incremental Cost for Storage No commercial benefit
- Test-bed for CO_2 Monitoring Technologies $30mm Research Project

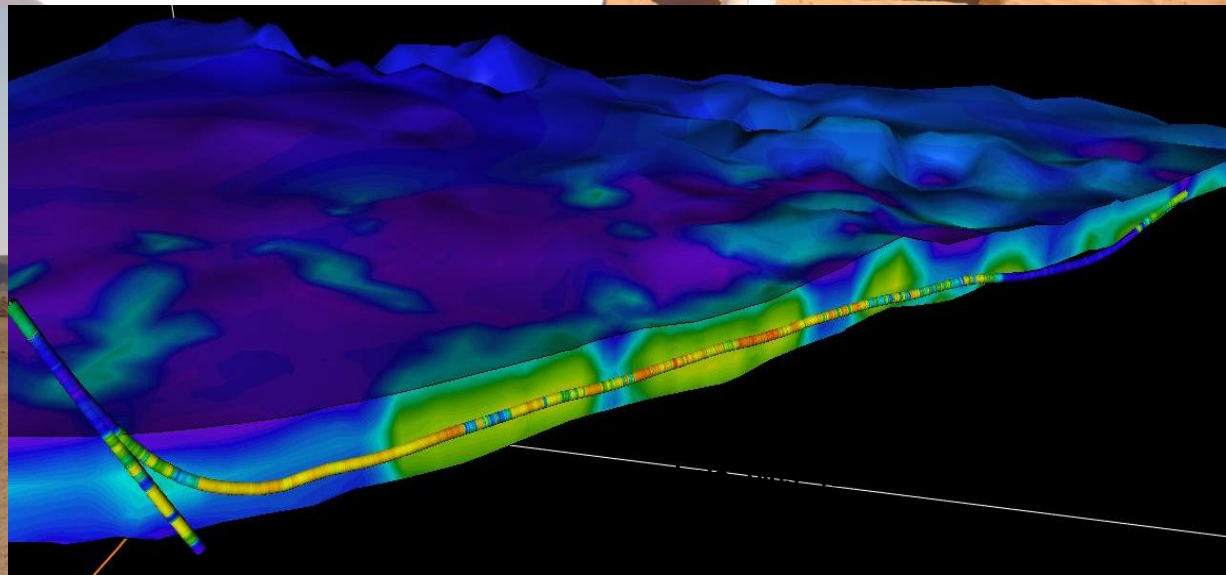
Additional CCS Infrastructure (CDM?)



CO_2 Compression and Storage

In Salah Gas
Stockage de CO_2

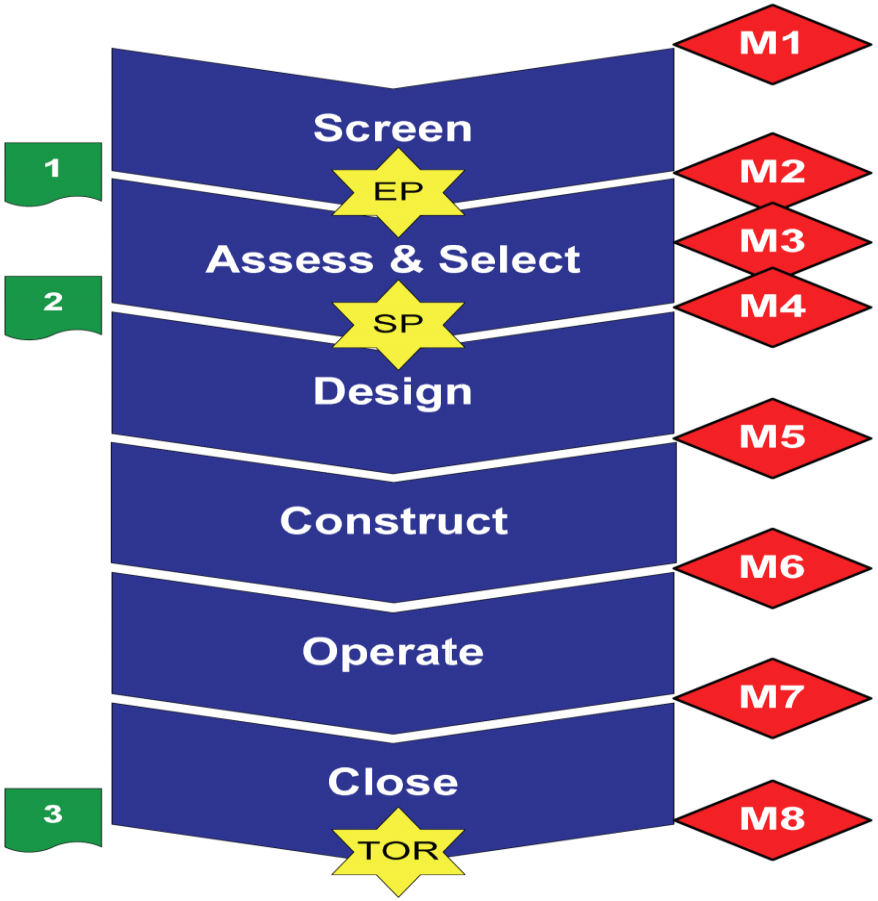
50mmscf/d CO_2 (1mmtpa)
Compression
Transportation
Injection
Storage



CGS Risk Profile

Risk Profile of a CGS Project

Oil & Gas Capital Value Process



Milestones

1) Begin site screening
2) Shortlist storage sites
3) Select site & engineering concept
4) Storage permit application
5) Initiate construction
6) Initiate CO_2 injection
7) Qualify for site closure
8) Initiate decommisioning

Qualification Statements

1) Statement of storage feasibility
2) Certificate of fitness for storage
3) Certificate of fitness for closure

Permits issued by Regulator

EP – Exploration Permit
SP – CO_2 Storage Permit
TOR – Transfer of Responsibility

(Ref: In Salah Case Study, DNV 2009)

Retrospective Compliance with EU CCS Directive

In Salah Gas Stockage de CO_2

Colour Key

- Compliant
- Compliance possible
- Non or difficult compliance

In Salah CO2 Storage vs. EU CCS Guidelines

Section	Category	Activities	Directive / MPCP	Storage Project Stages: Assessment / Appraise	Characterisation / Select/Define	Development / Execute	Operation / Operate	Closure / Decommission
GD1 Life Cycle Risk Management								
2.1	**Life Cycle Risk Management**	Periodic Risk Assessment and Management						
		Model and performance Uncertainty assessment						
3.3	**Life Cycle Phases**							
	Characterisation	Characterisation/assessment of storage complex						
		Detailed Risk Assessment						
		Develop injection, monitoring, corrective measures plans						
	Development	Detailed engineering design of the storage scheme						
		Baseline pre-injection monitoring						
	Operations	Reporting of monitoring results to Competent Authority (CA)						
		Development of Corrective measures plan						
		New data used to update models and risk assessment						
		Monitoring plans to be updated and verified						
		Notify CA of any leakage or significant irregularities						
	Closure	Develop monitoring plan with targets and methods						
		Conduct post closure monitoring						
		Updated site characterisation and risk assessment						
		Inspections by CA post closure						
	Pre-Transfer to CA	Prove long term containment of CO2						
		Monitor and assess for **20 years**						
		Site sealed and facilities removed						
6	**Risk Management for Geological Storage**	Use CO2Qualstore risk assessment methodology (DNV 2010a)						
		Dialogue on Risk management with CA						

In Salah CO_2 Joint Industry Project (JIP)

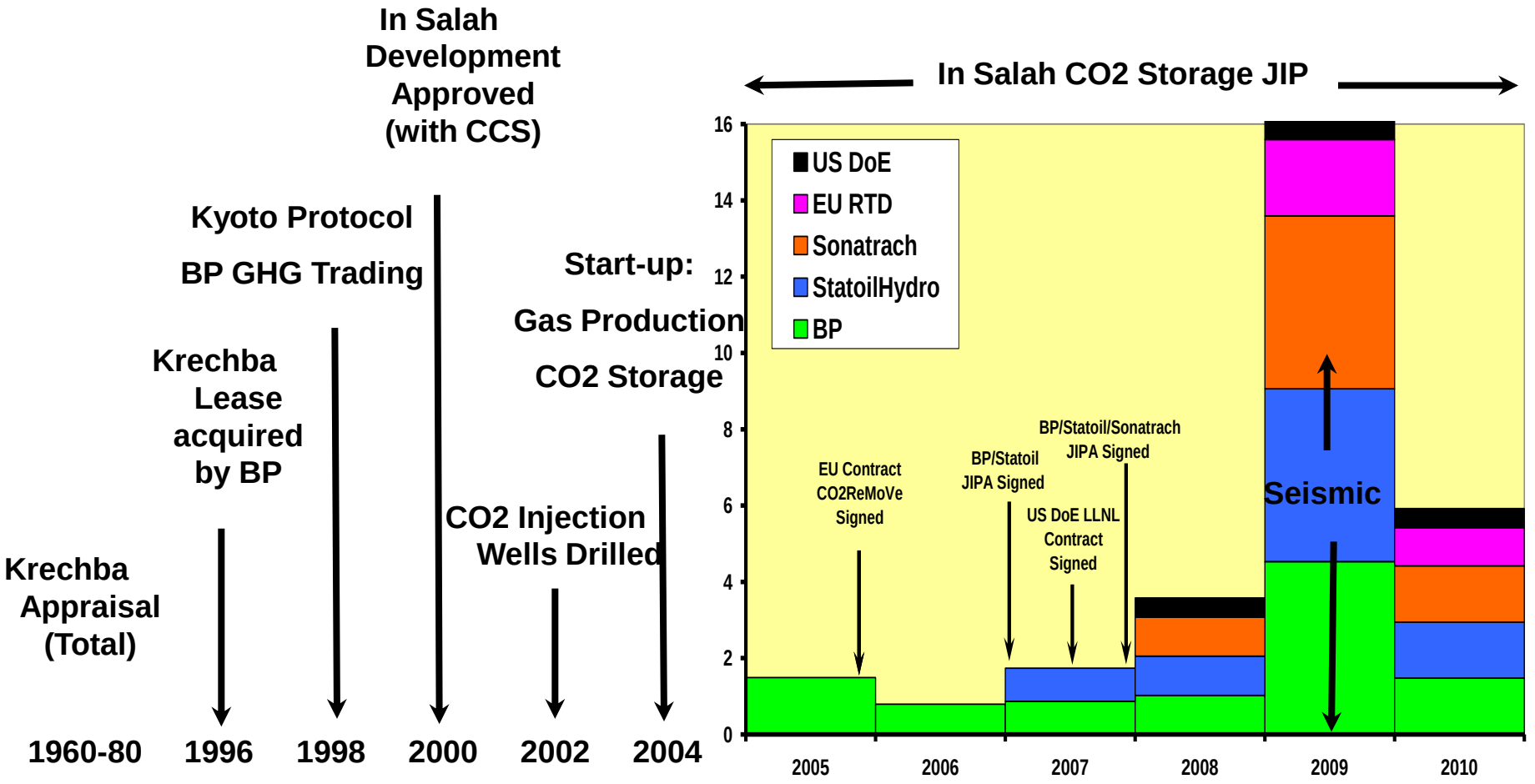
Objectives (2005-10)

1. **Provide assurance that secure geological storage of CO_2 can be cost-effectively verified and that long-term assurance can be provided by short-term monitoring.**

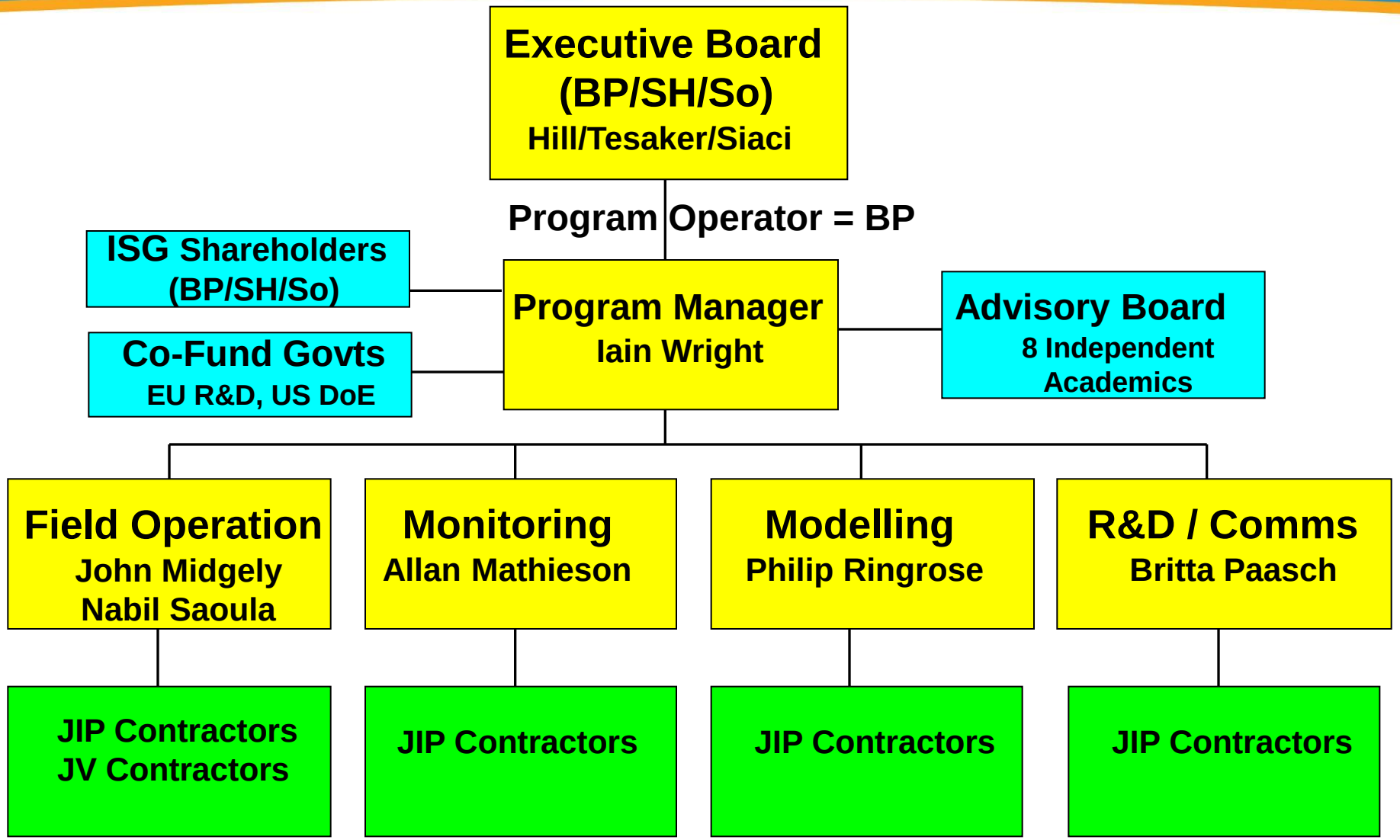
2. **Demonstrate to stakeholders that industrial-scale geological storage of CO_2 is a viable GHG mitigation option.**

3. **Set precedents for the regulation and verification of the geological storage of CO_2, allowing eligibility for GHG credits**

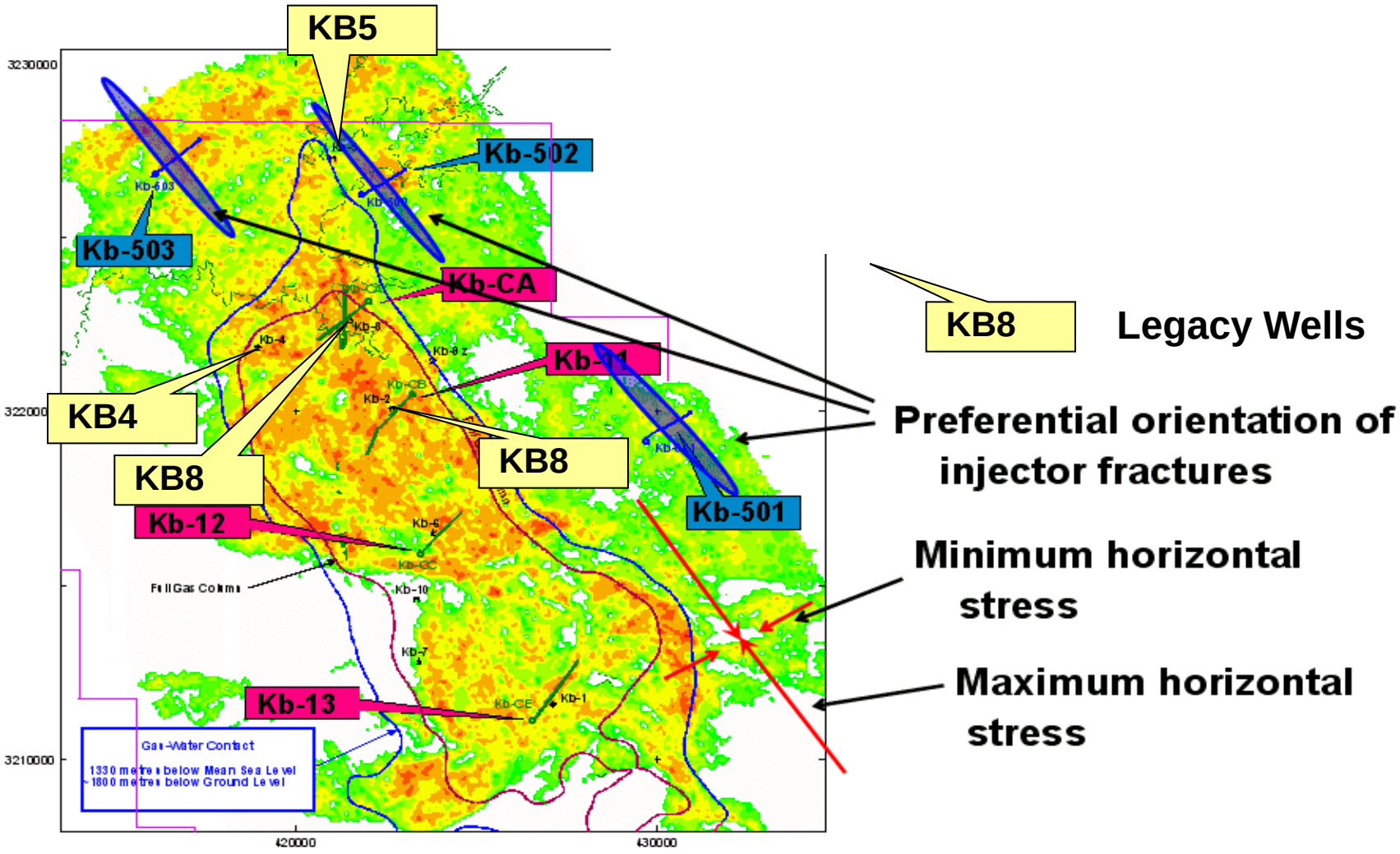
Joint Industry Project: Timeline



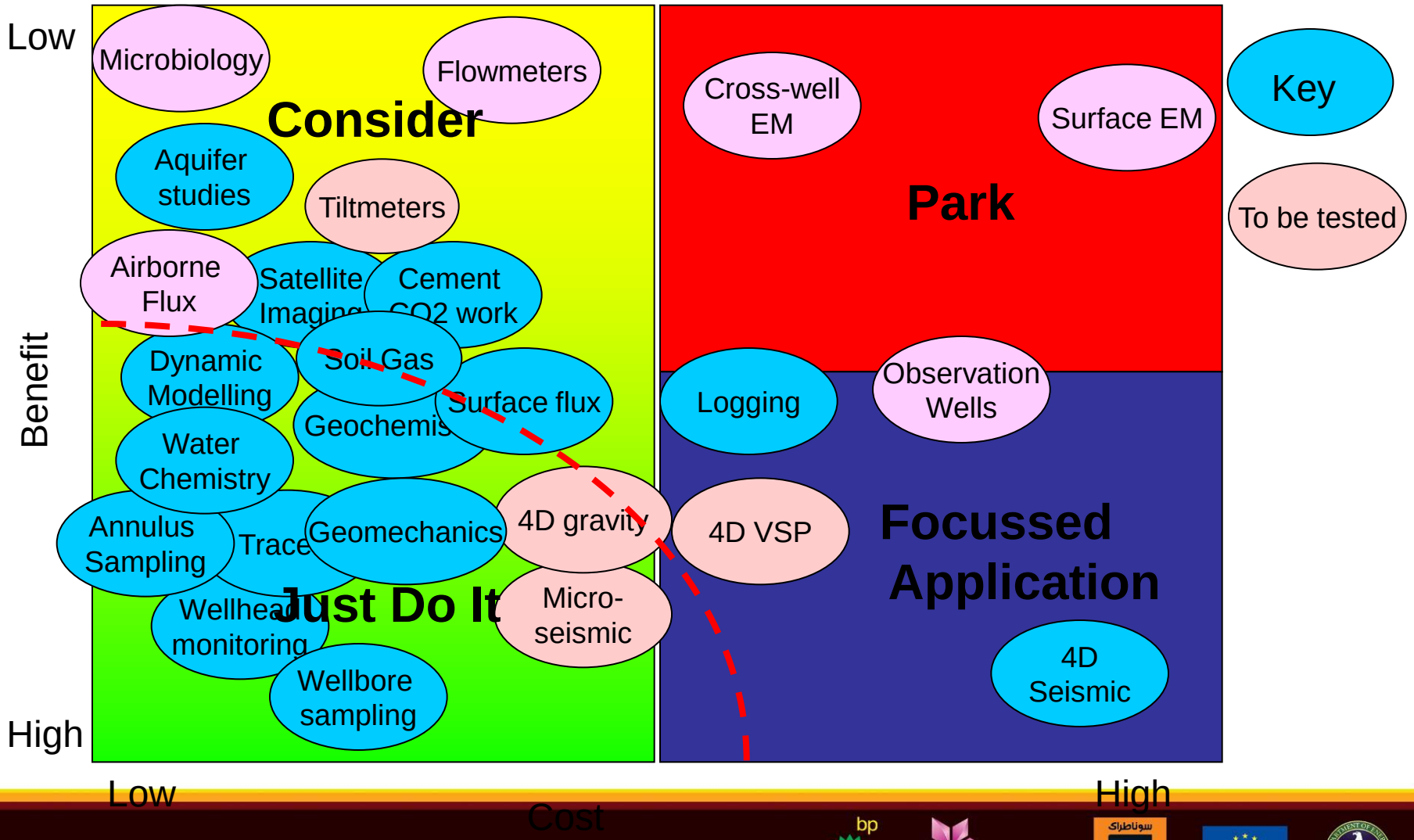
In Salah JIP Organisation (2010)



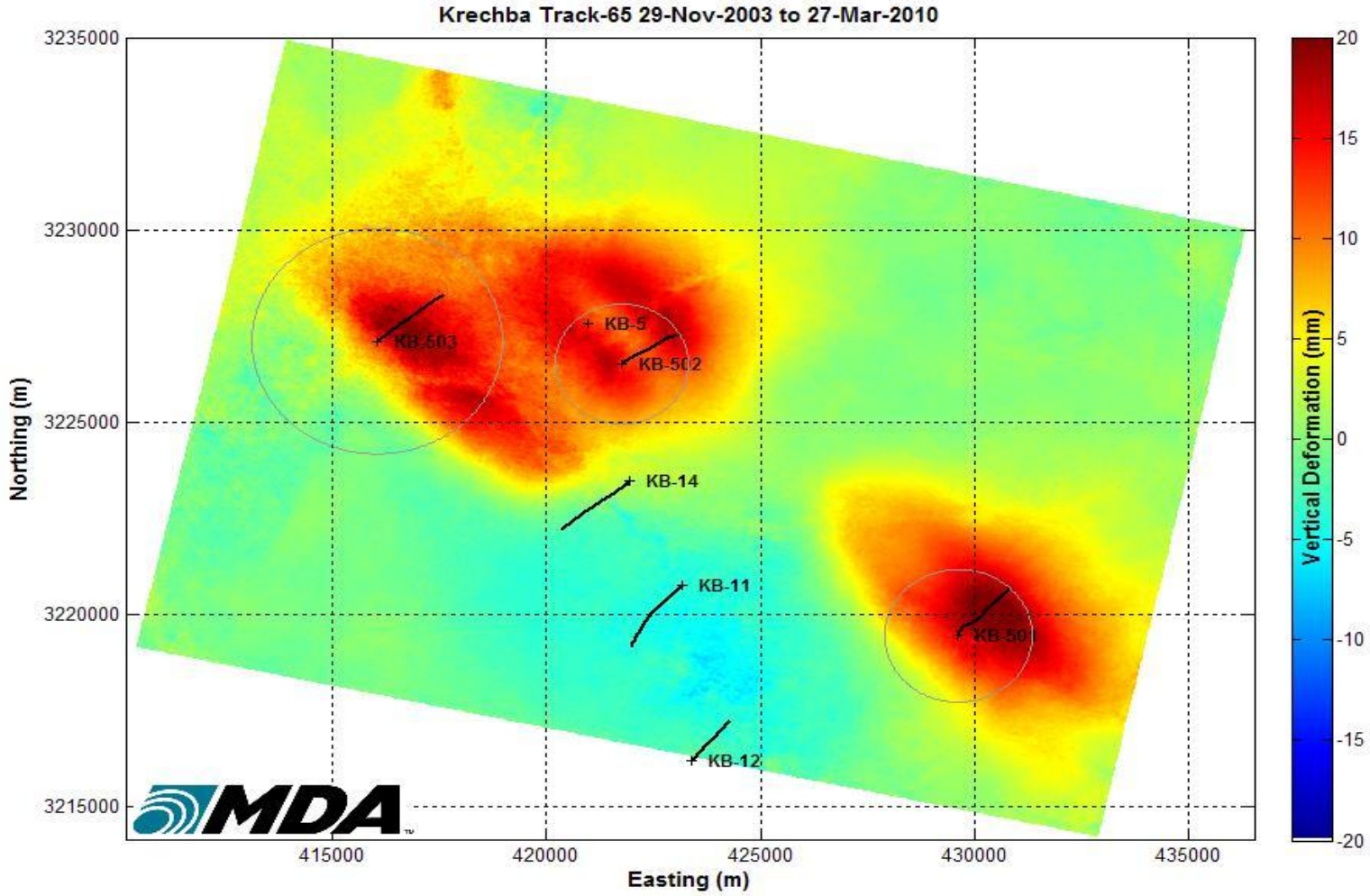
Expected CO_2 Migration



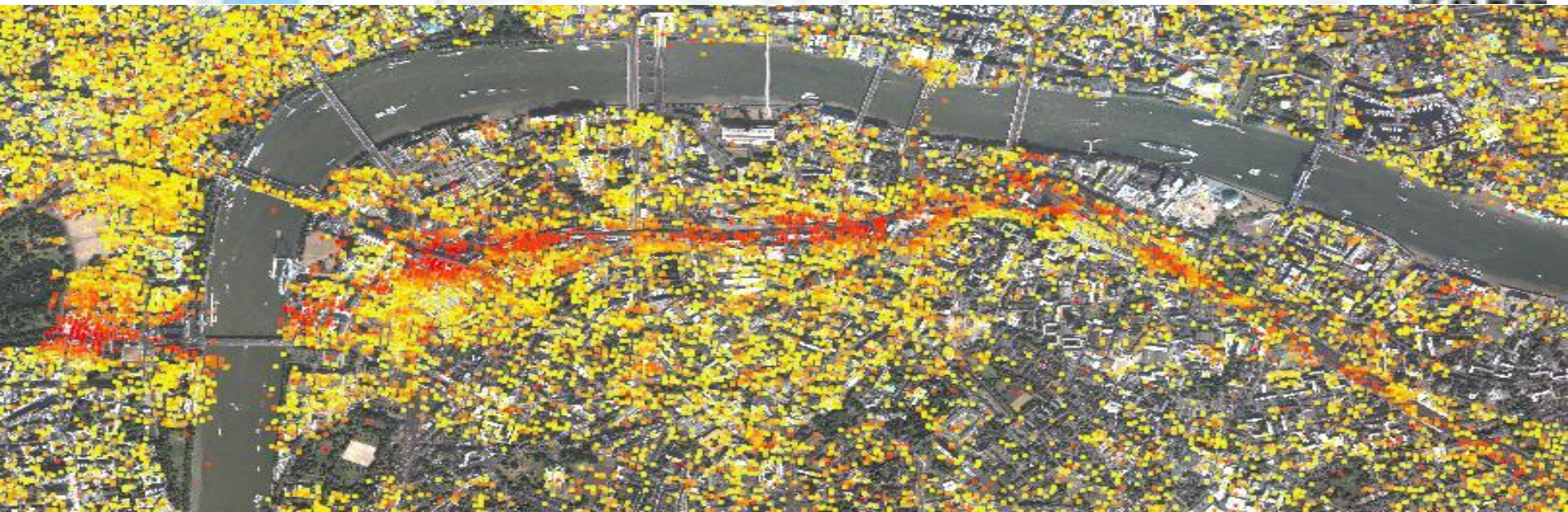
Monitoring Technologies -Evolution



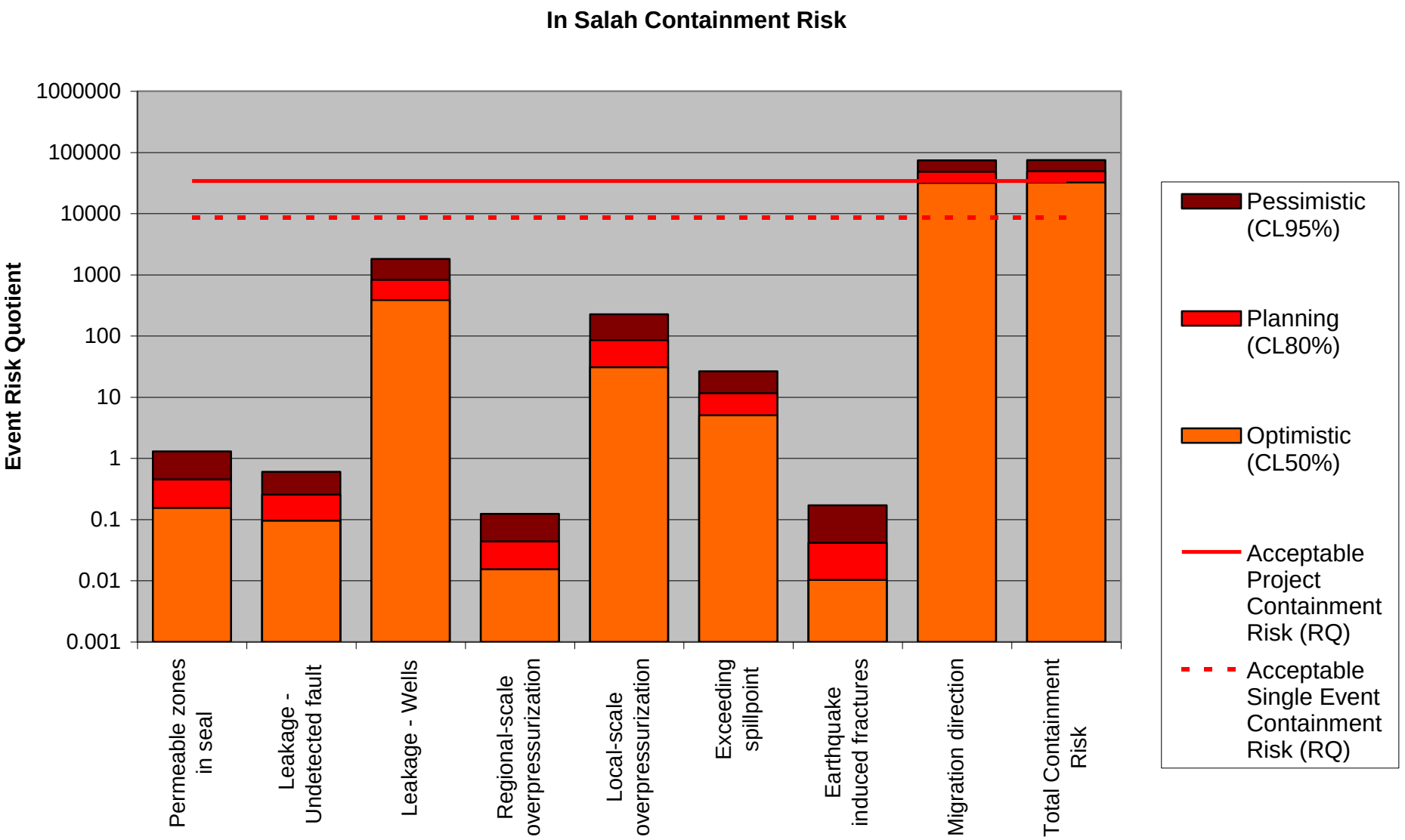
InSAR at End March 2010



InSAR: London Jubilee Line Construction



2008 Quantified Risk Assessment

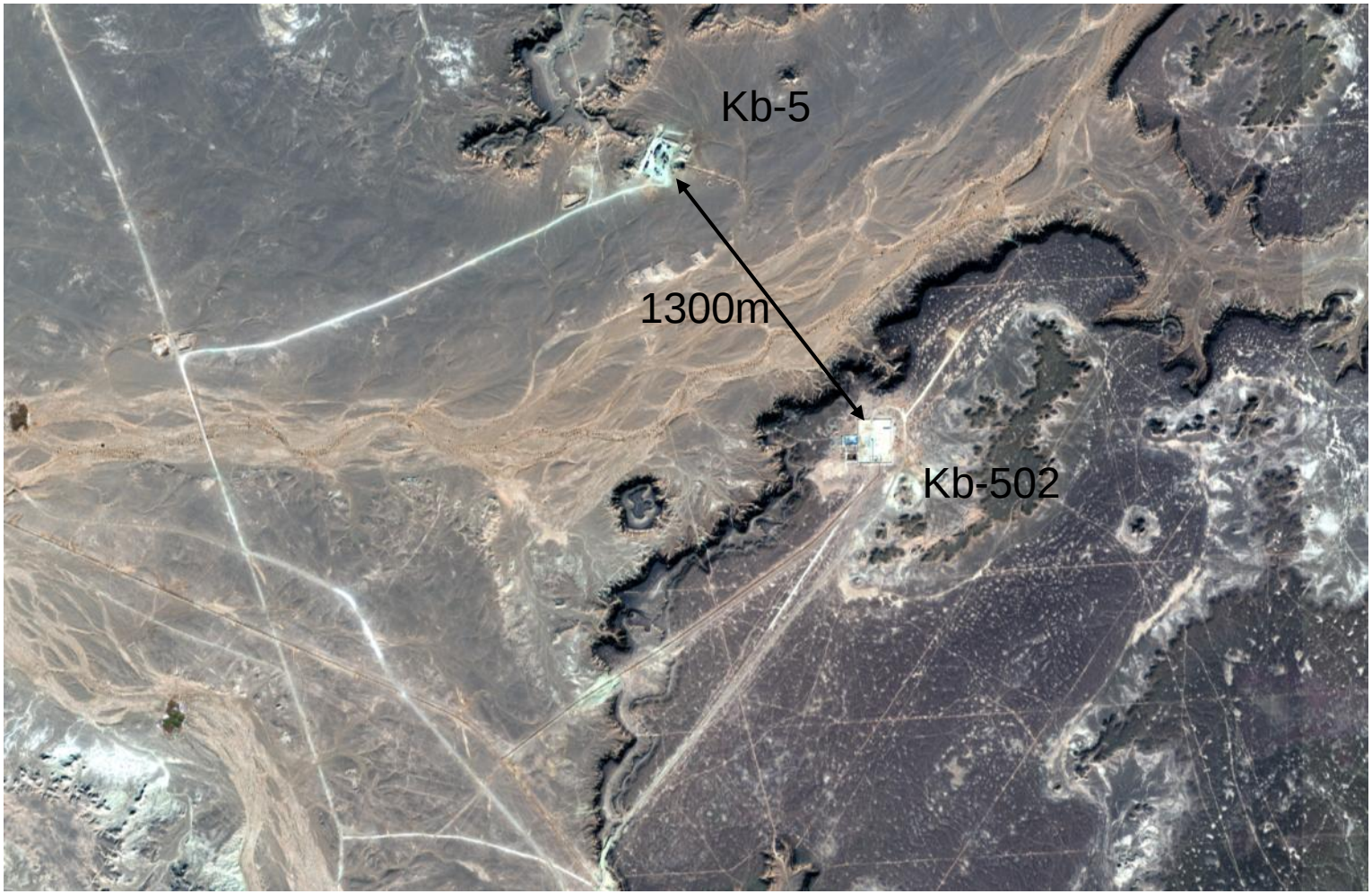


Focus on Two Topics

1. **Well Integrity: KB-5**

2. **Seismic Interpretation**

Focus on: KB-5 Decommissioning



KB-5: July 2007

CO_2 breakthrough occurred at KB-5 between inspection intervals (August 2006 to June 2007)

Detected by leak from valve (should have been pressure on a gauge)

Approx. 0.1 tonne CO_2 escaped (3.2 million tonnes stored)

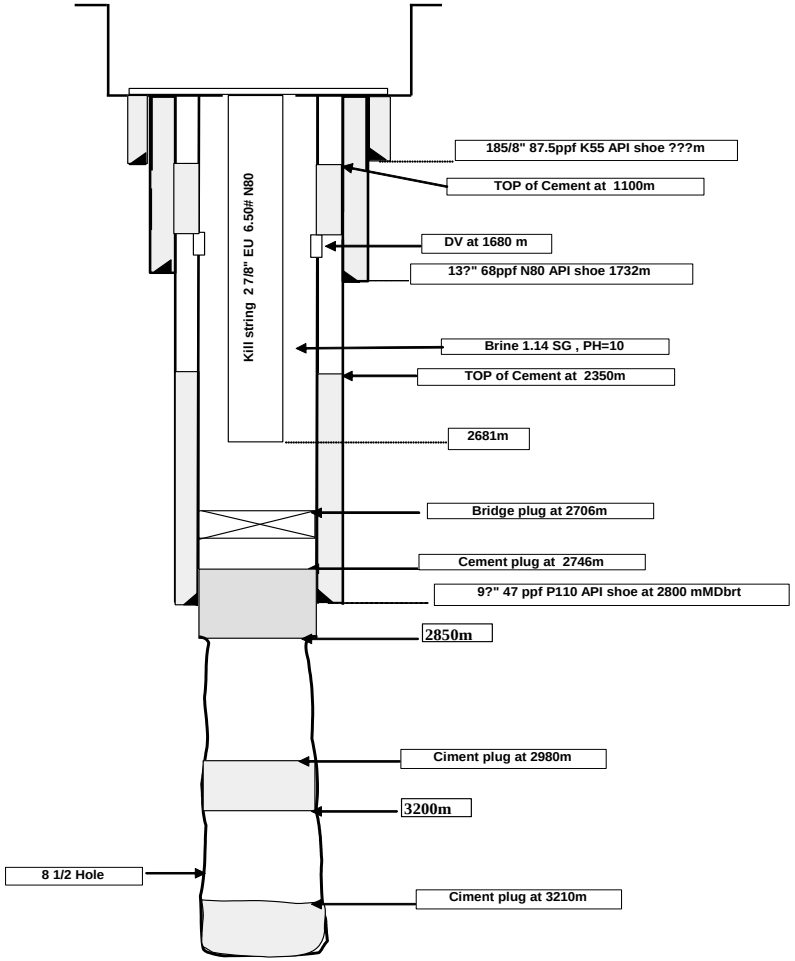
Flange and gauge fitted

CO_2 injection at Kb-502 stopped during KB-5 decommissioning

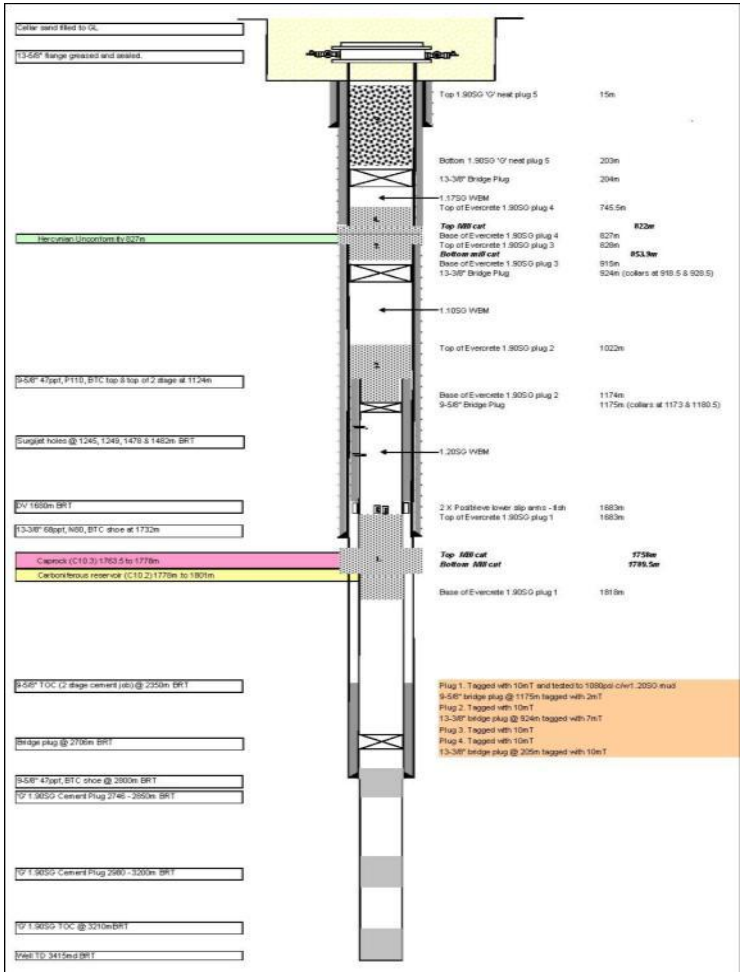
KB-5 Completion Diagrams

In Salah Gas Stockage de CO_2

Before (1981)



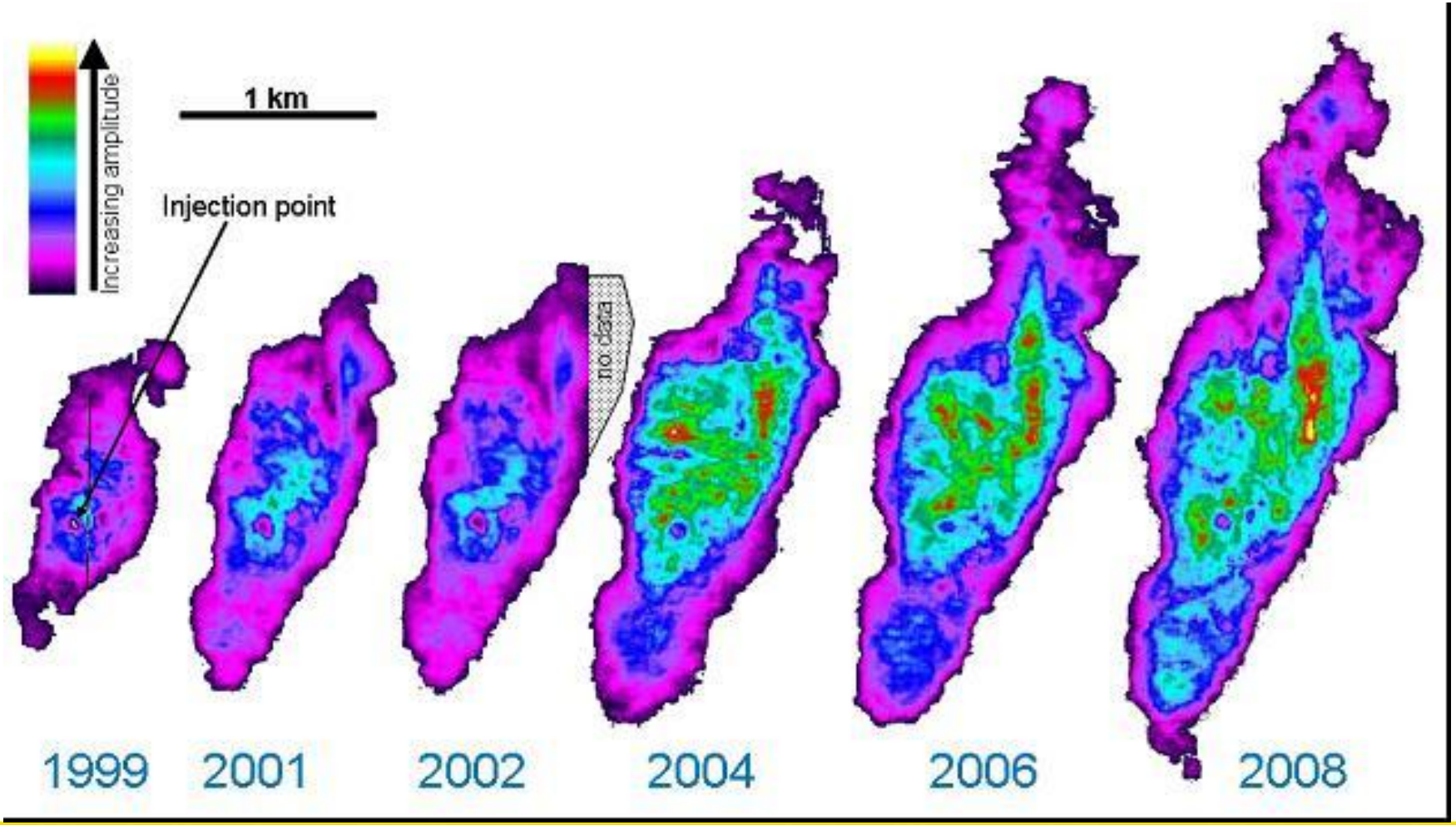
After (2009)



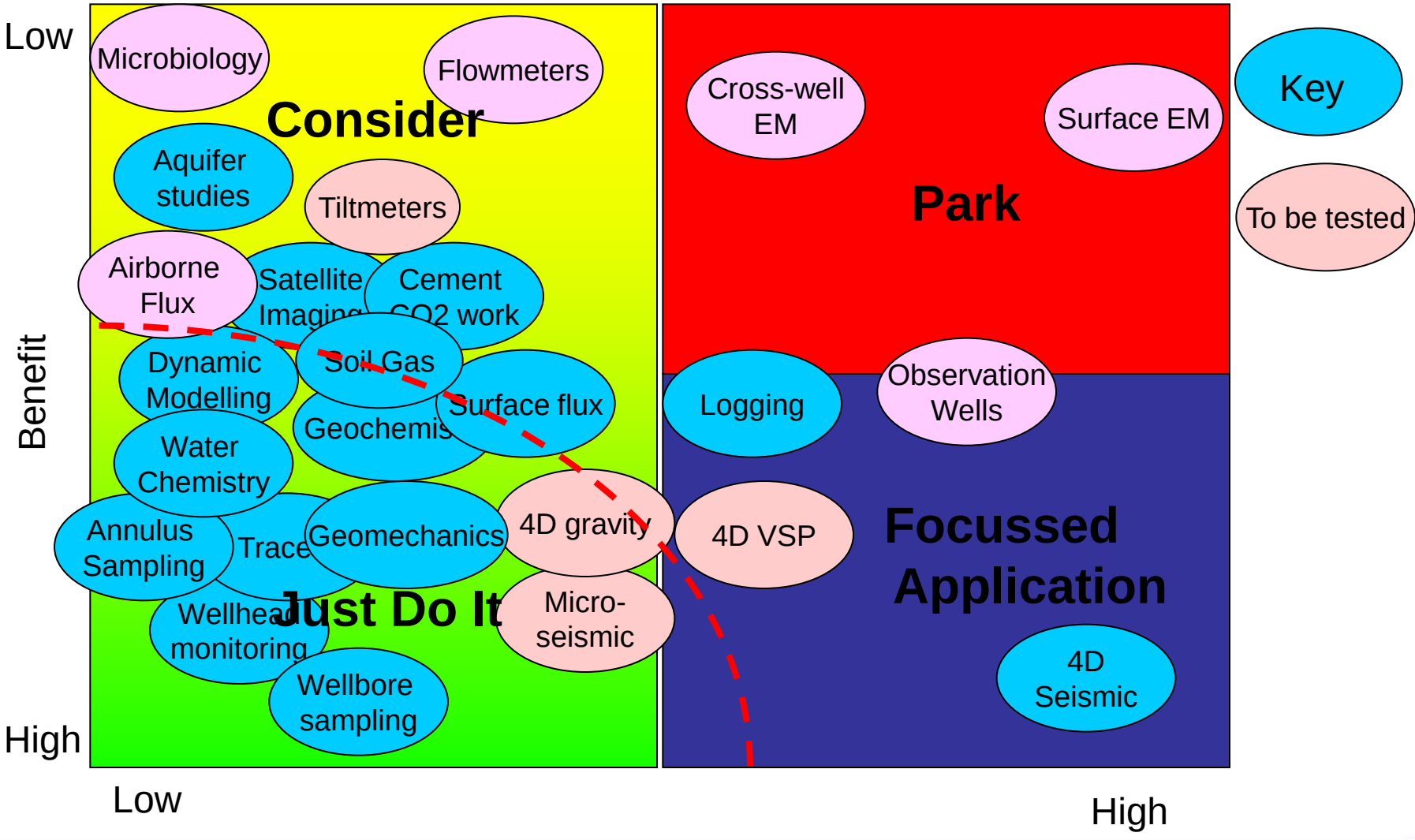
Focus on Seismic Interpretation

In Salah Gas
Stockage de CO_2

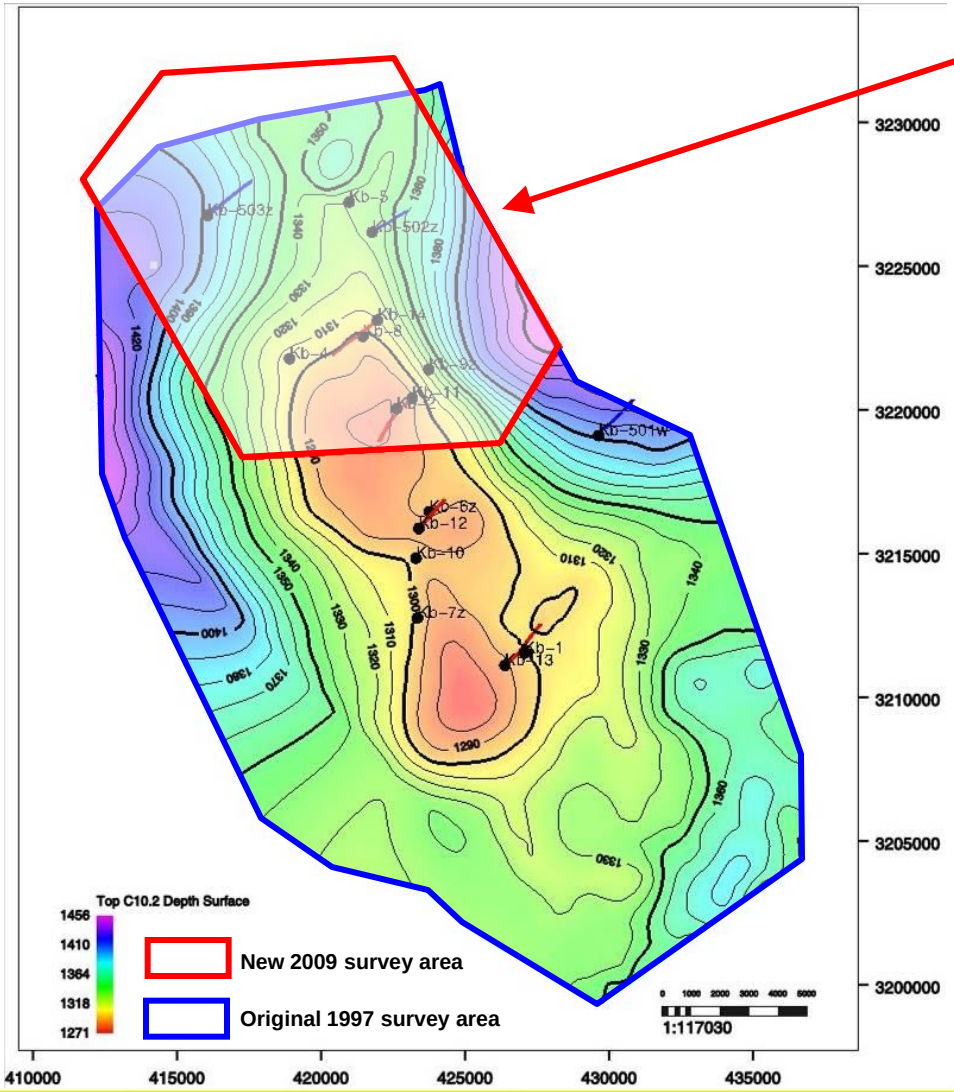
- **Sleipner Precedent: Seismic is the preferred monitoring technology**



Seismic at Krechba is very Expensive



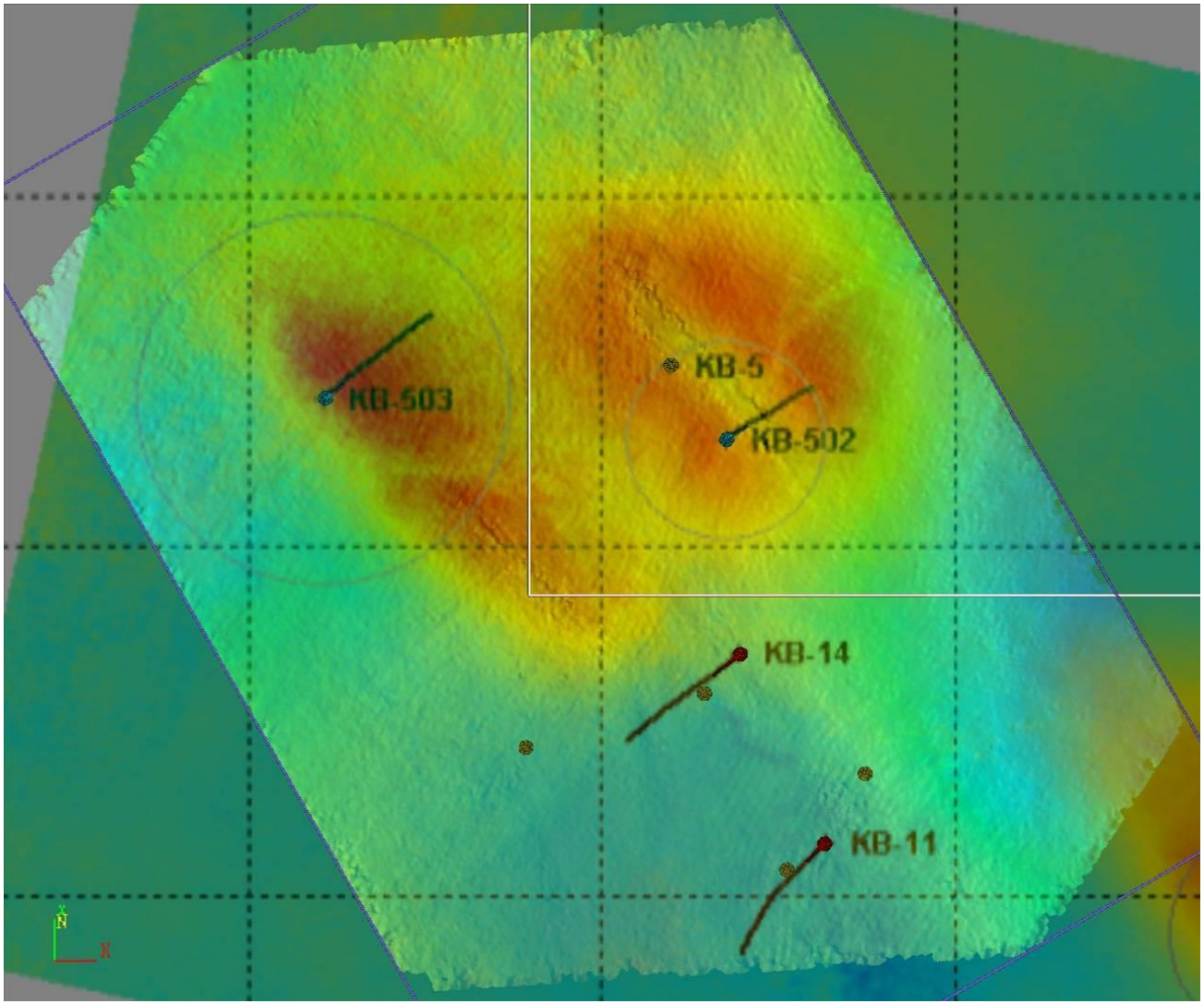
Seismic Survey Only Covered 2 of 3 CO_2 Plumes



2009 3D survey – covers only northern part of Krechba field, extends slightly further to N (into neighbouring licence block), includes:

- **Kb-2, Kb-4, Kb-5, Kb-8, Kb-9z, Kb-16z and Kb-17z exploration & appraisal wells**
- **Kb-11 & Kb-14 gas production wells**
- **Kb-502z & Kb-503z CO_2 injection wells**

Seismic Aligns with Satellite Deformation



In Salah CCS: Conclusions

- **Pioneering (Industrial-Scale) CCS project:**
  - **Successful CO_2 storage: > 5years, > 3mm tonnes stored, 19 GHGT10 Papers**
- **Excellent collaboration: IOC/NOC/Government/Academia**
- **Injection operations very much as anticipated**
- **Site selection and management is more important than monitoring**
- **Monitoring programmes will be very site-specific:**
  - **InSAR (Satellite) and Wellhead data are very cost-effective**
  - **Seismic very useful, but complex and expensive**
- **CO_2 plume/pressure is not homogenous**
  - **Needs high resolution data for appropriate characterisation**
  - **Have modified the storage operation based on lessons learned**

What Next?

- **Phase 1: 2006-2010**
- **In Salah is a "data-rich" project in a "data-poor" environment**
- **Phase 2: 2011-2015**
  - **LLNL, LBNL**

JIP2: US DoE Program (2010-2012)

Technical Task	Lab
Geomechanics/Geochemistry: Coupled modelling	LLNL
Satellite Imagery: stochastic inversion	LLNL
Satellite Imagery: deterministic inversion	LBNL
Satellite Imagery: Interpretation	LBNL
Seismic: Fracture analyses	LBNL
Geomechanics: Induced Microseismicity	LLNL
Geomechanical Response: Microseismic	LBNL
Geomechanical Response: Coupled modelling	LBNL
Geochemistry: Modelling of caprock/shallow aquifer	LLNL

Questions?

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Stockage de CO_2

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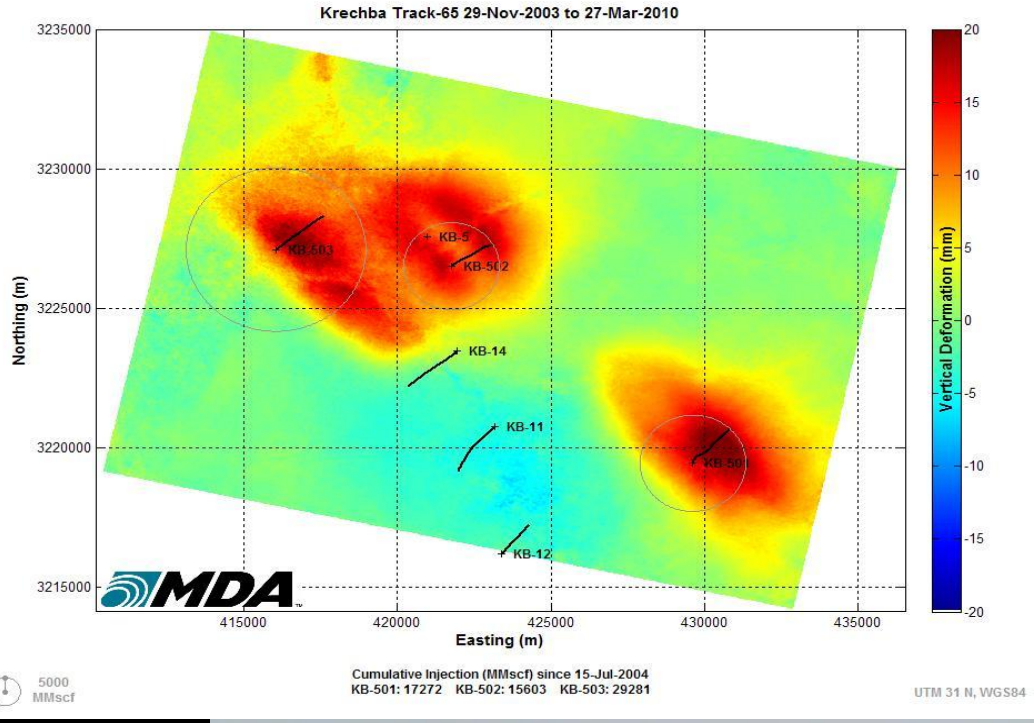

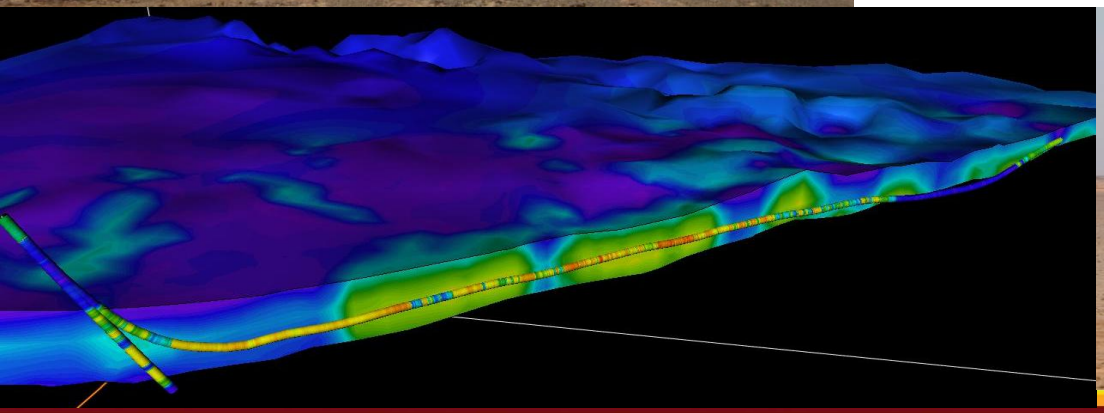

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